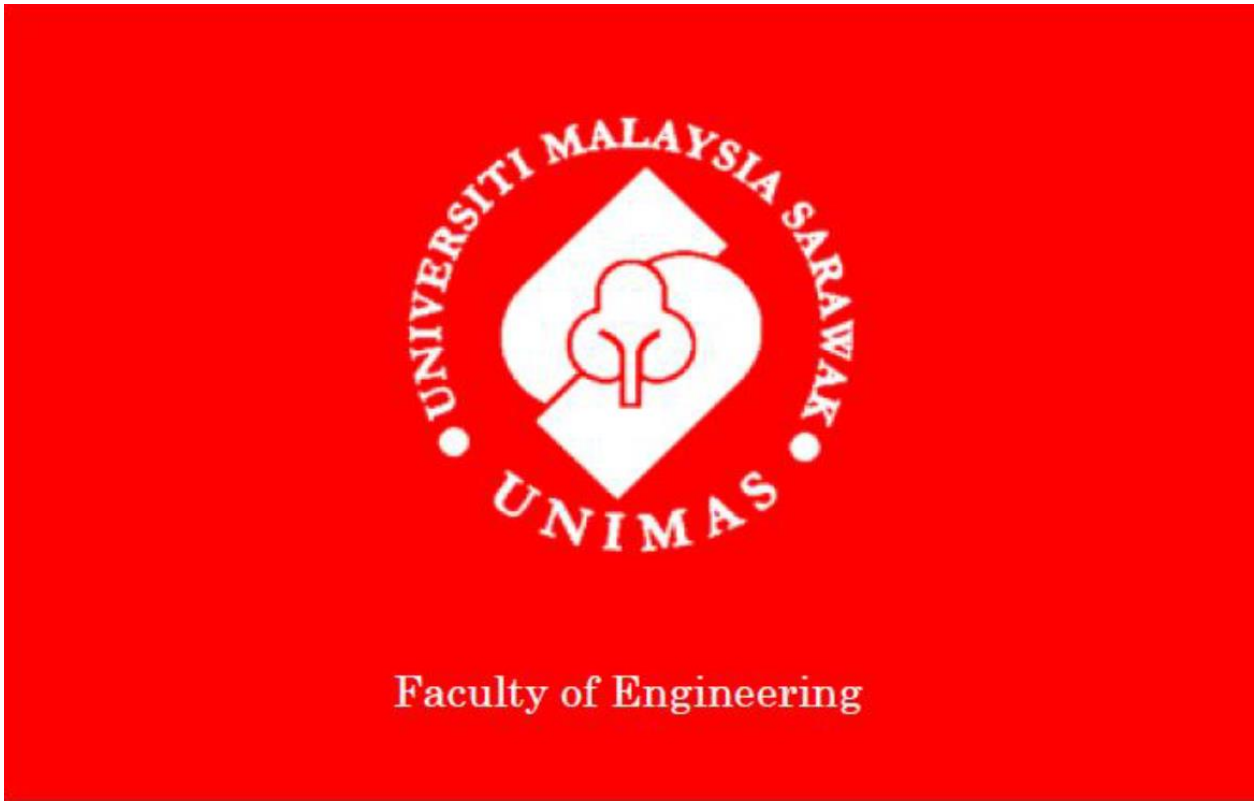

DEVELOPMENT OF A LABORATORY MODEL TO STUDY MECHANICS OF SLURRY DEPOSITION SUBJECTED TO TEMPERATURE INCREASE

Andreana Allyssa Anak Henry

Bachelor of Engineering with Honours

(Civil Engineering)

2017

UNIVERSITI MALAYSIA SARAWAK

Grade: _____

Please tick (√)

Final Year Project Report	√
Masters	
PhD	

DECLARATION OF ORIGINAL WORK

This declaration is made on the 11 day of JULY 2017.

Student's Declaration:

I ANDREANA ALLYSSA ANAK HENRY, 40568,FACULTY OF ENINEERING hereby declare that the work entitled DEVELOPMENT OF A LABORATORY MODEL TO STUDY MECHANICS OF SLURRY DEPOSITION SUBJECTED TO TEMPERATURE INCREASE is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

11/7/2017
Date submitted

ANDREANA ALLYSSA ANAK HENRY
(40568)

Supervisor's Declaration:

I DR.ALSIDQI HASAN hereby certifies that the work entitled DEVELOPMENT OF A LABORATORY MODEL TO STUDY MECHANICS OF SLURRY DEPOSITION SUBJECTED TO TEMPERATURE INCREASE was prepared by the above named student, and was submitted to the "FACULTY" as a * partial/full fulfillment for the conferment of BACHELOR OF ENGINEERING (HONS) IN CIVIL ENGINEERING, and the aforementioned work, to the best of my knowledge, is the said student's work.

Received for examination by: _____ Date: 11/7/2017

DR. ALSIDQI HASAN

I declare that Project/Thesis is classified as (Please tick (√)):

☐ **CONFIDENTIAL** (Contains confidential information under the Official Secret Act 1972)*
☐ **RESTRICTED** (Contains restricted information as specified by the organisation where research was done)*
☑ **OPEN ACCESS**

Validation of Project/Thesis

I therefore duly affirmed with free consent and willingness declare that this said Project/Thesis shall be placed officially in the Centre for Academic Information Services with the abiding interest and rights as follows:

- This Project/Thesis is the sole legal property of Universiti Malaysia Sarawak (UNIMAS).
- The Centre for Academic Information Services has the lawful right to make copies for the purpose of academic and research only and not for other purpose.
- The Centre for Academic Information Services has the lawful right to digitalise the content for the Local Content Database.
- The Centre for Academic Information Services has the lawful right to make copies of the Project/Thesis for academic exchange between Higher Learning Institute.
- No dispute or any claim shall arise from the student itself neither third party on this Project/Thesis once it becomes the sole property of UNIMAS.
- This Project/Thesis or any material, data and information related to it shall not be distributed, published or disclosed to any party by the student except with UNIMAS permission.

Student signature _____ (11.7.2017)

Supervisor signature: _____ (11/7/2017)

Current Address:
SUBLOT 46, LORONG 21D, FASA 2, TAMAN SAMARINDAH, JALAN DATUK MOHD MUSA, 94300, KOTA SAMARAHAN, SARAWAK

Notes: * If the Project/Thesis is **CONFIDENTIAL** or **RESTRICTED**, please attach together as annexure a letter from the organisation with the period and reasons of confidentiality and restriction.

[The instrument is duly prepared by The Centre for Academic Information Services]

DEVELOPMENT OF A LABORATORY MODEL TO STUDY MECHANICS OF SLURRY DEPOSITION SUBJECTED TO TEMPERATURE INCREASE

ANDREANA ALLYSSA ANAK HENRY

A dissertation submitted in partial fulfilment

of the requirement for the degree of

Bachelor of Engineering with Honours

(Civil Engineering)

Faculty of Engineering

Universiti Malaysia Sarawak

2017

Dedicated to my beloved parents and my other members of the family who always bestow me sustainable motivations, advices and encouragements

ACKNOWLEDGEMENTS

First and foremost, I would like to thank to my supervisor, Dr. Alsidqi Hasan of Universiti Malaysia Sarawak from Civil Engineering department for his guidance and support throughout the completion of this final year project.

I am also thankful to Ting Wee Kiet, Master student, in the Department of Civil Engineering for sharing his expertise, sincere valuable guidance and knowledge extended to me. A sincere thanks also goes to the geotechnical laboratory technician, Hj Affendi Othman for his guidance during all those laboratory work done.

I would like to thank my family members especially my parents for the unceasing encouragement, love, support and attention to complete my four year undergraduate study. Nevertheless, I am also grateful to my partner who supported me throughout this venture. I take this opportunity to express my gratitude to all my fellow friends for their help and support.

ABSTRACT

Cemented slurry is a mixture of fine materials, cement and water. Fine materials that used in this research are silica flour. Cemented slurry has been widely used in industrial application which the main application is the mine backfill. Previous study only shows the data collection on the materials itself which is lack in information on the behaviour of total stress to the materials due to the temperature increase. Scaled down replication model is designed to test the behaviour of the proposed material whereby the temperature acts as a controlling factor. This research is to investigate the effect of temperature increase during the deposition of cement slurry within narrow walls. The effect of temperature rise in cemented slurry during the cementation, which expands the cemented slurry volume that involves the exothermic reaction between cement and water. The constraint condition in the narrow walls causing the cemented slurry unable to expand thus causes the total stress to increase. By developing new laboratory model which is the narrow walls model, total stress of cemented slurry is observed throughout the curing process during deposition test with variation of temperature range. The expected outcome from this research, the total stress of the deposition material will increase due to the high temperature. Laboratory model is designed and fabricated to investigate the stress behaviour of cemented slurry under the same boundary condition of mining stope.

ABSTRAK

Pes simen adalah dihasilkan daripada bahan halus, simen dan air. Bahan halus yang digunakan dalam kajian ini adalah tepung *silica* yang diperolehi secara komersial. Pes simen sering digunakan dalam bidang industry perlombongan. Hasil daripada kajian yang lalu, informasi berkaitan kesan tekanan disebabkan peningkatan suhu kurang dikaji oleh para penyelidik. Kajian yang dijalankan semasa projek tahu akhir ini ini adalah untuk mengenal pasti kesan tekanan daripada peningkatan suhu kepada pemendapan pes simen. Replikasi model *narrow walls* direka bentuk untuk mengenalpasti kesan terhadap pemendapan pes simen jika peningkatan suhu dijadikan pembolehubah semasa melakukan kajian ini. Keadaan di dalam *narrow walls* yang sempit akan menyebabkan pemendapan pes simen tidak dapat mengembang dan akan menyebabkan jumlah tekanan kepada pemendapan pes simen meningkat. Penghasilan model makmal baharu yang dinamakan *narrow walls* digunakan untuk mengenalpasti kesan terhadap pes simen semasa ujian pemendapan dijalankan dengan menggunakan kadar peningkatan suhu yang berbeza. Hasil daripada kajian ini dijangka akan menyebabkan jumlah tekanan kepada pemendapan pes simen untuk meningkat jika peningkatan suhu semakin tinggi. Model makmal baharu direkabentuk berdasarkan ruang perlombongan untuk mengkaji tekanan terhadap pes simen.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

℃	-	Degree Celsius
%	-	Percentage
σ_v	-	Vertical stress
σ_h	-	Horizontal stress
μm	-	Micrometre
mm	-	Millimetre
l	-	Litres
g	-	Gram
R^2	-	Coefficient of determination
δ	-	Friction angle
K	-	Earth pressure coefficient
K_a	-	Active earth pressure
$\emptyset$	-	Internal friction angle
γ	-	Shear strain
exp	-	Exponent
sin	-	Sine
tan	-	Tangent
cos	-	Cosine
$\alpha(t)$	-	Degree of cement hydration with time
τ	-	Shear stress
φ	-	Friction angle
c	-	Cohesion

LIST OF ABBREVIATIONS

ASTM	-	American Standard Testing Method
SEM	-	Scanning electron microscope
USCS	-	Unified soil classification system
UCS	-	Unconfined compressive strength
CPB	-	Cemented paste backfill
UCPB	-	Uncemented paste backfill
CTB	-	Cemented tailing backfill
HPHTC	-	High Pressure High Temperature Consistometer
OPC	-	Ordinary Portland Cement

CHAPTER 1

INTRODUCTION

1.1 Background of Research

This research is to investigate the effect of the temperature increase in the total stress during the cemented slurry deposition and hydration in narrow wall based on the development of new laboratory model as shown in Figure 1.1. The temperature effect are determined to relate the quantitative relationship between temperature increase and the total stress. The application of stress distribution related to this study has been applied in mine backfilling, storage in silo and oil well application.

. Cemented slurry is formed by mixing fine materials with water. This is one of the materials that have been studied for producing cemented backfill. In this study, cemented slurry deposition was determined whereby the deposition takes place in narrow opening with friction walls. The factors affecting cemented slurry based on total stress propagation during deposition within the narrow walls by investigating the effect of temperature increase and the effect of wall friction. Silica flour is the main material used in producing cemented slurry in this research. However, this study is only concerned of the temperature increase and the effect of wall friction to determine the total stress propagation during the deposition of cemented slurry.

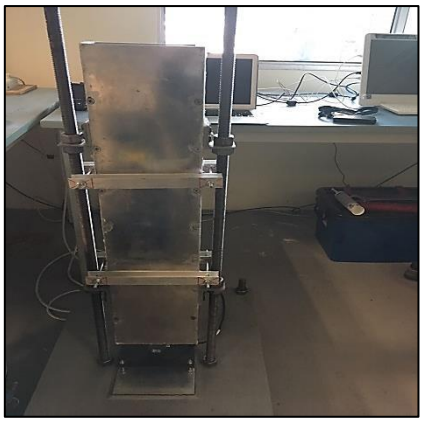

Figure 1.1: Narrow wall model

1.2 Problem Statement and research gap

Stress distribution of deposition materials in narrow wall has been proposed by Janssen. However, the Janssen theory only develops for the effect of depth, H with the total stress propagation with constant temperature. It is further developed into model that is adapted in trenches, model with cohesion consideration, 3D approach, and a 3D cohesive model with the consideration of thermal as an influential parameter. The study of this research has lack of knowledge regarding on the behaviour of cemented slurry to behave in narrow wall condition. Most of the previous research found is based on the material testing alone. For example, the properties of the cemented slurry in the geothermal well condition are different from the condition of the cemented slurry in the narrow walls.

1.3 Hypothesis

Based on the problems statements above, the hypothesis that will be investigated in this research:

i. The effect of temperature rise in the cemented slurry during the cementation, which expands the cemented slurry volume that involves the exothermic reaction between cement and water. The constraint condition in the narrow walls prevents cemented slurry from expanding causing the total stress to increase.

ii. Time dependent progressive shear failure along the interfacial surface between cemented slurry and walls, which counteracts the arching mechanism. Hence, the total stress can be delayed. Progressive failure can occur if the shear strains damage the cementation bond. The shear failure mobilizes the cemented slurry mass downward.

1.4 Aim and objectives

The aim of this research is to create experimental approach to understand the behaviour of cemented slurry under different temperature.

The objectives listed below are set to comply and achieve the aims of this research and scope of works in relation with this final year project title:

i. To investigate the effect of temperature to total stress propagation with respect to time in depositing cemented slurry within a narrow friction walls.
ii. To establish empirical mathematical formulation on the temperature effect to the total stress propagation.

1.5 Scope of study

The focus of this study is to conduct the experiments on the basic properties test of silica and deposition test of the uncemented slurry and cemented slurry. Deposition test is the main test that is conducted in this research study. Scope of this study has limit to one mix proportion which is to be determined at later stage.

1.6 Project significance

Cemented slurry is a heterogeneous material used to fill up stope generated during ore recovery. This technique is known as cemented paste backfill. Various heat sources during the deposition are the cause of expansion in cemented slurry and results in additional pressure on the structure and rock mass. Laboratory scale replication on mining stope is design and fabricated.

1.7 Thesis outline

In this thesis there are five main chapters.

Chapter 1: Introduction

Briefly explain the background of the study, scope of works and aims and objectives.

Chapter 2: Literature review

Literature review in recent research findings and historical development towards the current study.

Chapter 3: Methodology

In this chapter, development of laboratory apparatus and test plan are briefly discussed on the total stress propagation, narrow wall friction and temperature increases. The procedures involve determining the basic properties of silica which is in accordance to American Standard Testing Method (ASTM) and deposition test to conduct the investigation on the uncemented slurry and cemented slurry.

Chapter 4: Results and discussions

The results and discussions from the basic properties test of silica and deposition test of uncemented slurry and cemented slurry.

Chapter 5: Conclusion and recommendations

The last chapter will conclude the investigation and analysis of the slurry deposition subjected to temperature increase. Recommendations are also included for future research works.

1.8 Work programme

Work programme of this study is to show the flow of the project work throughout the research study.

Event / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2016														
Material Preparation														
Silica Powder														
Basic Index Properties Testing														
Hydrometer Test														
Specific Gravity Test														
Atterberg Limit (Liquid Limit & Plastic Limit Test)														
Direct Shear Test														
FYP 1 Report														
Chapter 1 - Introduction														
Chapter 2 - Literature Review														
Chapter 3 - Methadology														
2017														
Deposition test														
FYP 2 Report														
Chapter 4- Results and Discussion														
Chapter 5- Conclusion														

Figure 1.2: Work programme for Final Year Project